Long-Term Endovascular Treatment Outcome of 46 Patients with Cavernous Sinus Dural Arteriovenous Fistulas Presenting with Ophthalmic Symptoms

A Non-Controlled Trial with Clinical and Angiographic Follow-up

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SUMMARY – *Ocular symptoms are regularly observed in patients with cavernous sinus dural arteriovenous fistulas (cDAVF). We aimed to evaluate the long-term efficacy and safety of endovascular approaches in patients with cDAVF presenting with different ocular symptoms. In a prospective study between June 2008 and March 2013, 46 patients with ocular symptoms due to cDAVF who were not eligible for conservative therapy, met the inclusion criteria and underwent endovascular treatment. They underwent a transarterial approach with histoacryl glue injections or transvenous coil embolization, all in one session. They were followed up for a mean period of 17.3 months (range 7 to 30 months) clinically and using angiography. The mean age of patients was 36.8 years (18-60) and 65% of them were male. All patients showed venous drainage into the superior and inferior orbital veins. Access to the cavernous sinus was transvenous in ten patients, transarterial in 26 patients, and mixed in ten patients. Initial symptoms were improved in 97.8% of patients and did not recur during the study follow-up. The procedural complications included: blurred vision, transient sixth nerve palsy and exacerbation of chemoproptosis in two, one and two patients respectively that completely resolved in initial weeks with no recurrence. No patient worsened or developed new symptoms suggestive of a recurrent fistula during the follow-up period. One patient experienced intracranial dissection of the internal carotid artery and ischemic stroke with an unfinished procedure. The relief of early presentation was durable in long-term follow-up and the cured lesions were stable in angiographic controls. Favorable and durable outcomes could be obtained following endovascular approaches for cDAVF presenting with different ocular symptoms.*

Introduction

Dural arteriovenous fistulas (DAVFs) account for 10%-15% of intracranial arteriovenous malformations, and the presence of a dural arterial supply and the absence of a parenchymal nidus differentiate them from parenchymal or pial arteriovenous malformations [1]. DAVFs occur in the transverse, sigmoid, and cavernous sinuses and most of them present in adulthood [2,3].

Cavernous sinus DAVFs (cDAVFs) form through an abnormal arteriovenous communication between the dural branches of the internal and external carotid arteries (ICA and ECA, respectively) and the cavernous sinus [4]. They occur less frequently than transverse/sigmoid sinus DAVFs and have a low risk of hemorrhage [5]. Some alarming ophthalmic symptoms, such as ophthalmic proptosis, extraocular muscle palsies, chemosis, visual loss, and diplopia, as well as intracranial bruits may develop in patients with cDAVF [6-8].

The main management approaches for cDAVFs have included observation, stereotactic radiosurgery, intermittent manual compression of the ICA, endovascular treatment (transarterial or transvenous embolization), and neurosurgery [9]. Endovascular techniques are the most commonly used treatment for patients with symptomatic cDAVFs that do not spontaneously resolve. However, recent investigations have indicated that embolization of cDAVFs is not a thoroughly safe procedure and may also be related to temporary ophthalmoplegia [10-12]. Not only are the surgical approaches difficult, but cDAVF embolization has a high rate of postoperative cranial nerve deficit and associated occlusion of the ICA [13]. Here we report our experience using transarterial, transvenous, or a mixed approach endovascular treatment in 46 cDAVF cases and describe the early and mid-term outcomes.

Methods

Patients and Methods

Between June 2008 and March 2013, 55 patients with suspected cDAVFs were referred by ophthalmologists to our institute and evaluated. Of these patients, 46 were not eligible for conservative therapy, met the inclusion criteria for our study, and underwent endovascular treatment. The inclusion criteria were the following: age between 18 and 65 years, ophthalmic symptoms suggestive of cavernous DAVFs, and positive computed tomography angiography findings. Patients who met these criteria and provided signed consent were included in the study. Patients with a history of any cerebrovascular anomalies, concurrent intracranial arteriovenous malformation or any cerebral aneurysm, space-occupying lesion, carotid surgery, stroke, or chronic disability were excluded.

All participants underwent examination by an ophthalmologist before treatment, and ophthalmic symptoms included chemosis, proptosis, eye redness, and blurred vision. Participants also reported having pulsatile tinnitus. Objective tests of visual acuity and visual fields were performed to provide baseline data for comparison after the endovascular procedure and during follow-up monitoring. Vascular risk factors included hypertension (receiving medication for hypertension or blood pressure >140/90 mm Hg on repeated measurements), diabetes mellitus (receiving medication for diabetes mellitus or fasting blood glucose level ≥126 mg/dl), dyslipidemia (receiving lipid-lowering agents or having an overnight fasting cholesterol level >200 mg/dl and low-density lipoprotein (LDL) > 100 mg/dl), current cigarette smoking (current smokers or those who quit smoking <6 months). A skilled neuroradiologist explained the benefits and potential risks of the endovascular therapy to the participants. The primary endpoint of the current investigation was the clinical and angiographic outcome of these patients after undergoing endovascular interventional therapy.

Procedures and Approaches

Patients were eligible for endovascular therapy only if conservative therapy was not suitable or if there was no other therapeutic option of acceptably low risk. The imaging results available for referred cases were reviewed by an interventional neuroradiologist at our institute before management decisions were made. We repeated angiography for several patients at our hospital before decisions could be made regarding management. The final decision to proceed with a transarterial or transvenous approach was made only after analysis of the clinical, imaging, and angiographic findings in each case. Patients who gave informed consent were transferred to the angiography room provided they had no contraindications for endovascular procedures (e.g., renal failure, coagulopathy, and contrast allergy). The patients underwent complete cerebral angiography, including both ICA and ECA for cDAVFs, as well as bilateral vertebral injections for diagnosis and identification of all arterial supplies to the fistulas. All cases received endovascular treatment with a transarterial or transvenous approach. Before intervention, the Borden classification [13] was used to classify fistulas based on their venous drainage: Type I, the dural arterial supply drains anterograde into the venous sinus; Type II, the dural arterial supply drains into the venous sinus, but high pressure in the sinus causes both anterograde drainage and retrograde drainage via subarachnoid veins; and Type III, the dural arterial supply drains retrograde into subarachnoid veins. The Borden classification scheme further subclassifies fistulas as having blood supplied from a single artery (a) or multiple arteries (b).

A transarterial approach was used through the ICA or ECA and then the feeding arteries. If the transarterial approach failed to reach the target or remained incomplete, a transvenous approach was done via the superior ophthalmic vein (SOV) or inferior petrosal sinus (IPS). Once the cavernous sinus was reached, catheterization and coil embolization of the compartments with outflow to dangerous venous connections to the ophthalmic vein branches were attempted. A transarterial approach was preferred if there was an accessible arterial supply. Transarterial procedures were performed with the patients under local anesthesia, and systemic heparinization was achieved during the procedures with heparin. The vascular anatomy was carefully examined prior to glue injections to identify potential external-to-internal carotid artery anastomoses and to avoid damage to the cranial nerve supply. The procedure was completed as soon as a control angiogram revealed complete occlusion of the fistula.

If a patient remained symptomatic after a transarterial procedure, transvenous coil embolization was undertaken. The arteriovenous shunts were approached via the venous routes of the SOV or IPS, and the detachable coils were selected according to the volume of the cavernous sinus. Patency of the ICA on the same side was checked frequently during intermittent injection of the embolic material. The procedure was ended when a control angiogram showed that the fistula was occluded.

Follow-up

All cases were followed up clinically (with detailed ophthalmologic examination) by outpatient visit at one, three, six and 12 months after the endovascular procedure and yearly thereafter until termination of follow-up. The patients were additionally instructed to visit their physician as soon as possible if ophthalmological or neurological symptoms occurred, even if it was not time for a scheduled follow-up. Outcomes were divided into two categories: clinical cure and anatomic cure. The clinical cure group included the patients in whom all symptoms disappeared despite a persistent shunt. An anatomic cure was defined as the disappearance of all symptoms with the angiographic demonstration of the obliteration of the fistula. During the follow-up period, clinical and angiographic assessments were attempted for all patients. The safety of these procedures was evaluated by the incidence of any procedure-related complications, including any adverse event during the procedure or within 30 days afterwards. Demographic features, vascular risk factors, arterial supply and venous drainage of fistula, presenting symptoms, endovascular approach via artery or vein or mixed approaches, classification of lesions, follow-up outcomes, and complications were recorded by an expert neuro-interventionist.

Results

Overall, 46 patients were evaluated. Patients' mean age was 36.83 ± 11.63 (18-60) years, and men predominated (65%). Eye redness and chemosis were the most common presenting symptoms. Patient characteristics are summarized in Tables 1-3. The mean interval between the onset of clinical symptoms and treatment of the fistula was 42 days (median, 25 days; range, 3-131 days). All patients showed venous drainage into the superior and inferior orbital veins, and all patients were treated in one session. Transarterial access was achieved in 26 patients (Table 1). Access to the cavernous sinus was transvenous in ten patients (Table 2) and ten patients underwent the procedure by mixed access (Table 3). Embolization of the cavernous sinus was technically successful and led to complete closure of the fistulas in all cases. Mean duration of follow-up was 17.3 months (range, 7-30 months). Borden type Ib was predominately seen in our cases (87%). Complications related to transarterial embolization procedures occurred in two patients (4%), and there were no complications related to transvenous embolization procedures. Four (8.6%) patients developed complications after mixed approach embolization.

Detailed examination revealed that ocular symptoms related to venous congestion (chemosis or proptosis) resolved completely in all affected patients except in two cases of transient exacerbation (cases 8 in Table 1 and 5 in Table 3) due to partial thrombosis during the procedure. For these cases, anticoagulant plus

Table 1 Summary of information in patients who underwent a transarterial approach with complications and follow-up results.

No	*Age (y)/sex*	*Signs & Symptoms at Presentation*	*Borden Lesion Type*	*Arteries*	*Veins*	*Complications & Treatment*	*F/U (m)*	*Outcome*	
								Angio-graphic	*Clinical*
1	25/M	Lt. eye redness & chemosis	Ib	APA/ MMA	Opht (S to Inf)	–	10	AC	SR
2	24/M	Lt. eye redness & chemosis	Ib	APA/ MMA	Opht (S to Inf)	–	9	AC	SR
3	26/M	Lt. eye redness & chemosis	Ib	APA/MMA	Opht (S to Inf)	–	14	AC	SR
4	35/M	Lt. eye redness & chemosis/ blurred vision	Ib	APA/MMA	Opht (S to Inf)	–	20	AC	SR
5	29/M	Lt. eye redness & chemosis	Ib	APA/MMA	Opht (S to Inf)	–	14	AC	SR
6	23/F	Rt. eye redness & chemosis/ tinnitus	Ib	APA/MMA	Opht (S to Inf)/ IPS	–	13	AC	SR
7	28/M	Lt. eye redness & chemosis/ tinnitus/proptosis	Ia	APA	Opht (S to Inf)	–	8	AC	SR
8	30/M	Lt. eye redness & chemosis/ proptosis	Ib	APA/MMA	Opht (S to Inf)	Partial thrombosis: exacerbation of chemosis/ anticoagulants	16	AC	SR during 6 weeks
9	36/M	Rt. eye redness & chemosis/ proptosis	II	APA/MMA	Opht (S to Inf)/ Sphenopalatine	–	15	AC	SR
10	40/M	Rt. eye redness & chemosis/ proptosis	Ib	ICA/APA	Opht (S to Inf)	–	12	AC	SR
11	33/F	Lt. eye redness & chemosis/ proptosis	Ia	MMA	Opht (S to Inf)/ IPS	–	13	AC	SR
12	39/M	Lt. eye redness & chemosis / proptosis	Ib	AEA/MMA	Opht (S to Inf)	–	13	AC	SR
13	36/F	Lt. eye redness & chemosis / proptosis	Ib	ICA/MMA	Opht (S to Inf)	–	28	AC	SR
14	28/M	Lt. eye redness & chemosis / proptosis	Ib	PEA/MMA	Opht (S to Inf)	Blurred vision/ Conservative	26	AC	SR during 1 week
15	18/M	Rt. eye redness & chemosis / Proptosis	Ib	APA/MMA	Opht (S to Inf)/ Bilat IPS	–	15	AC	SR
16	32/M	Lt. eye redness & chemosis / proptosis/tinnitus	Ib	ICA/APA	Opht (S to Inf)	–	11	AC	SR
17	45/F	Rt. eye redness & chemosis / proptosis	Ib	ICA/MMA	Opht (S to Inf)/ IPS	–	24	AC	SR
18	50/M	Lt. eye redness & chemosis / proptosis/headache	II	ICA/Anterior deep temporal	Opht (S)/SPS	–	15	AC	SR
19	53/F	Rt. eye redness & chemosis / proptosis	II	ICA/APA	Opht (S to Inf)/ Sphenopalatine	–	7	AC	SR
20	56/M	Lt. eye redness & chemosis	Ib	APA/MMA	Opht (S to Inf)	–	8	AC	SR
21	58/F	Rt. eye redness & chemosis	Ib	APA/MMA	Opht (S to Inf)/ IPS	–	13	AC	SR
22	41/M	Rt. eye redness & chemosis	Ib	APA/MMA	Opht (Inf)/IPS	–	10	AC	SR
23	43/F	Lt. eye redness & chemosis/ tinnitus	Ib	APA/MMA	Opht (S to Inf)	–	26	AC	SR
24	38/M	Lt. eye redness & chemosis/ tinnitus	Ib	Occipital/ MMA	Opht (S to Inf)	–	23	AC	SR
25	42/F	Rt. eye redness & chemosis / Proptosis	Ib	APA/MMA	Opht (S to Inf)	–	29	AC	SR
26	32/M	Lt. eye redness & chemosis / Proptosis	Ib	APA/MMA	Opht (S to Inf)/ IPS	–	30	AC	SR

AC: angiographically cured (complete occlusion); *AEA*: anterior ethmoidal artery; *APA*: ascending pharyngeal artery; *CS*: cavernous sinus; *F*: female; *FU*: follow-up period of time; *ICA*: internal carotid artery; *IPS*: inferior petrosal sinus; *Lt*: left; *M*: male; *MMA*: middle meningeal artery; *Opht (s to inf)*: ophthalmic vein (superior to Inferior); *PEA*: posterior ethmoidal artery; *Rt*: right; *SPS*: superior petrosal sinus; *SR*: symptom relief.

Table 2 Summary of information in patients who underwent a transvenous approach with complications and follow-up results.

No.	*Age (y)/sex*	*Signs & Symptoms at Presentation*	*Borden Lesion Type*	*Arteries*	*Veins*	*Complications & Treatment*	*F/U (m)*	*Outcome*	
								Angio-graphic	*Clinical*
1	60/M	Rt. eye redness & chemosis/ tinnitus	Ib	ICA/MMA	Opht (S to Inf)/ IPS	–	15	AC	SR
2	37/M	Rt. eye redness & chemosis/ tinnitus	Ib	ICA/APA	Opht/IPS	–	28	AC	SR
3	22/M	Rt. eye redness & chemosis/ tinnitus	Ib	APA/ICA/ MMA	Opht (S to Inf)/ IPS	–	19	AC	SR
4	25/M	Bilat. eye redness & chemosis	Ib	ICA/APA	Opht (S)/IPS	–	21	AC	SR
5	60/M	Lt. eye redness & chemosis/ tinnitus	Ib	ICA/ recurrent of foramen rotundom	Opht (S to Inf)	–	16	AC	SR
6	30/M	Lt. eye redness & chemosis/ tinnitus	Ib	ICA/APA	Opht (S to Inf)/ SPA	–	25	AC	SR
7	23/F	Lt. eye redness & chemosis Proptosis	Ib	ICA/APA	Opht (S to Inf)/ IPS	–	14	AC	SR
8	46/F	Lt. eye redness & chemosis/ Proptosis	Ib	ICA/APA/ MMA	Opht (S to Inf)/ IPS	–	16	AC	SR
9	30/M	Lt. eye redness & chemosis/ Proptosis	Ib	ICA/MMA	Opht (S to Inf)	–	15	AC	SR
10	41/M	Lt. eye redness & chemosis/ Proptosis/ tinnitus	Ib	APA/MMA	Opht (S to Inf)/ IPS	–	21	AC	SR

AC: angiographically cured (complete occlusion); *AEA*: anterior ethmoidal artery; *APA*: ascending pharyngeal artery; *CS*: cavernous sinus; *F*: female; *FU*: follow-up period of time; *ICA*: internal carotid artery; *IPS*: inferior petrosal sinus; *Lt*: left; *M*: male; *MMA*: middle meningeal artery; *Opht (s to inf)*: ophthalmic vein (superior to Inferior); *PEA*: posterior ethmoidal artery; *Rt*: right; *SPS*: superior petrosal sinus; *SR*: symptom relief.

antiplatelet therapy was begun and continued for six weeks until the symptoms were relieved and angiography was normal (Figure 1).

Another two cases (cases 14 in Table 1 and 10 in Table 3) had transient decreased visual acuity and blurred vision, which improved spontaneously. One patient (case 8 in Table 3) had periprocedural transient diplopia (caused by sixth cranial nerve palsies), and one patient (case 9 in Table 3) experienced intracranial dissection of the ICA during the procedure and was affected by ischemic stroke. Overall, there were five transient complications (11%) and one permanent complication (2%).

One patient (case 14 in Table 1) had decreased visual acuity and blurred vision, but regained normal vision within a few days after the procedure was completed. Among the ten patients who underwent the mixed approach, one had an exacerbation of her chemosis and proptosis (case 5 in Table 3) and one case had blurred vision (case 10 in Table 3) that resolved completely during the observation period. One patient (case 8 in Table 3) had sixth cranial nerve palsies that experienced normalization during follow-up monitoring. One 60-year-old patient with a history of hypertension and diabetes (case 9 in Table

Table 3 Summary of information in patients who underwent a mixed transarterial and transvenous approach with complications and follow-up results.

No	*Age (y)/sex*	*Signs & Symptoms at Presentation*	*Borden Lesion Type*	*Arteries*	*Veins*	*Complications & Treatment*	*F/U (m)*	*Outcome*	
								Angio-graphic	*Clinical*
5	42/F	Lt. eye redness & chemosis	Ib	ICA/APA	Opht (S to Inf)/ IPS	–	21	AC	SR
6	47/F	Lt. eye redness & chemosis	Ib	ICA/MMA	Opht (S to Inf)	–	26	AC	SR
9	50/M	Lt. eye redness & chemosis/ blurred vision	Ib	ICA/APA	Opht (S to Inf)/ IPS	–	19	AC	SR
10	47/M	Rt. eye redness & chemosis/ blurred vision	Ib	ICA/MMA	Opht (S to Inf)/ IPS	–	18	AC	SR
13	30/F	Lt. eye redness & chemosis	Ib	APA/MMA	Opht (S to Inf)	Partial thrombosis: exacerbation of chemosis & proptosis/ anticoagulants	22	AC	SR during 6 weeks
22	19/M	Lt. eye redness & chemosis/ proptosis/ tinnitus/ Headache	Ib	APA/MMA	Opht (S to Inf)/ IPS	–	16	AC	SR
26	24/F	Lt. eye redness & chemosis/ proptosis	Ib	ICA/MMA	Opht (S to Inf)	–	12	AC	SR
35	32/F	Lt. eye redness & chemosis/ tinnitus	II	ICA/APA/ MMA	Opht (S to Inf)/ IPS/ Sphenopalatine	Injury to cranial nerve in CS: Transient 6th nerve palsy/ conservative	17	AC	SR during 4 weeks
40	60/F	Lt. eye redness & chemosis/ proptosis	Ib	ICA/MMA	Opht (S to Inf)	ICA Dissection: stroke	–	Flow reduction	–
46	29/M	Lt. eye redness & chemosis/ proptosis	Ib	ICA/MMA	Opht (S to Inf)/ IPS	Blurred vision/ conservative	16	AC	SR during 2 weeks

AC: angiographically cured (complete occlusion); *AEA*: anterior ethmoidal artery; *APA*: ascending pharyngeal artery; *CS*: cavernous sinus; *F*: female; *FU*: follow-up period of time; *ICA*: internal carotid artery; *IPS*: inferior petrosal sinus; *Lt*: left; *M*: male; *MMA*: middle meningeal artery; *Opht (s to inf)*: ophthalmic vein (superior to Inferior); *PEA*: posterior ethmoidal artery; *Rt*: right; *SPS*: superior petrosal sinus; *SR*: symptom relief.

3) experienced intracranial dissection of the ICA during the procedure and subsequent ischemic stroke of left middle cerebral artery. The stroke regimen was immediately begun but she died three months into the follow-up period as a result of the stroke. Data from this patient were excluded from further analysis.

Forty-five patients (98%) experienced complete obliteration of their cDAVFs as demonstrated in follow-up angiograms obtained at least seven months after the last procedure. An anatomic cure was achieved in all cases. Clinical cure was observed in 40 of 45 cases (89%). No patient worsened or developed new symptoms suggestive of a recurrent fistula during the follow-up period. Except for case 9 in Table 3, none of the patients had an occlusion of the ICA, and no patient presented with symptoms of cerebral infarction in the follow-up examination.

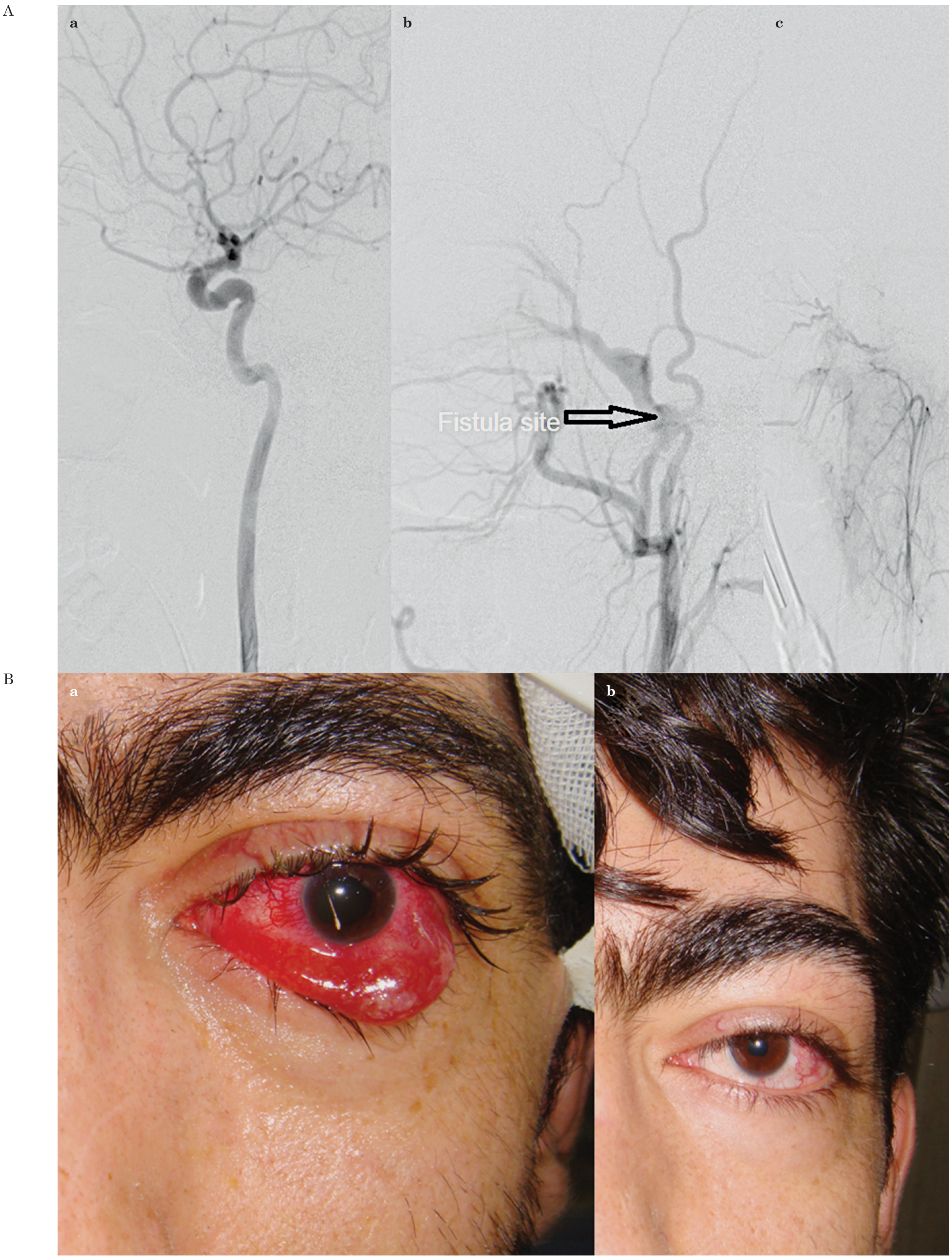

Figure 1 A 30-year-old man with chemosis and redness of left eye. Investigations including DSA showed dural AVF with supply from the left side external carotid artery. There was no accessory supply from the internal carotid or ascending pharyngeal arteries (A- a and c) .The patient showed exacerbation of symptoms following transarterial occlusion of the fistula (B-a). He underwent medical treatment and showed a significant improvement a few weeks later (B-b).

Discussion

The linchpin of DAVF therapy is treatment via endovascular approaches [15,16], but the expertise of a multidisciplinary team comprising an interventional neuroradiologist, neurosurgeon, neurologist, and an ophthalmologist is needed for optimal results. Before proceeding with any treatment, careful assessment of a patient should be conducted, including clinical presentation; demographics; presence of comorbidities and their type, location, and classification; and the angiographic features of lesion [17]. Most previous investigations did not focus on neuro-ophthalmologic findings in detail or demonstrate the overall clinical outcome in patients after endovascular treatment of cDAVF [18].

The current study shows the efficacy and durability of endovascular embolization for cDAVF and significant regression of ophthalmologic involvement in a series of 46 cases. We used transarterial glue embolization as the primary treatment for intracranial DAVF due to its safety and effectiveness [19,20]. This approach was applied in more than half (n = 26) of the cases, and it safely yielded successful results that extended through the follow-up period. In ten cases (21.7%) in which this approach was not possible or failed, transvenous access of the target sinus was done with successful results. We were able to achieve complete obliteration of the fistula in 100% of cases, with cure or improvement of symptoms in all cases on clinical follow-up.

In some studies, transvenous embolization using coils for curative purposes has been demonstrated to be very effective (complete occlusion in 80%–100% of cases) or anatomic and clinical cure rates of 71%–89% and 77%–96% in cDAVF cases, respectively [8,21,22]. However, serious complications associated with vascular damage and intracranial hemorrhage have also been reported [8,23]. Insufficient embolization leads to a worsening of symptoms due to increased pressure in the venous system. Also, to achieve success, procedures must include a precise assessment of diagnostic images and clinical conditions [17]. During the procedure, immediate occlusion of cavernous sinus outlets to prevent drainage to dangerous venous systems should be done. Therefore, prior to coils being placed, it is important to evaluate the compatibility of the microcatheter with all outlets of the cavernous sinus. Furthermore, the procedure should be done within the shortest possible time to prevent increased pressure in other drainage veins during embolization [6]. In this regard, the anterior approach is beneficial because the posterior part of the cavernous sinus can be embolized first. Embolization of the posterior compartment of the cavernous sinus, where feeding arteries mainly occur, can reduce shunt flow and the risk of increasing venous pressure in most cases [24]. We applied this method in our cases that underwent coil embolization. When dangerous and symptomatic venous drainage systems are occluded, the cavernous sinus can be embolized by placing the coils in the shunting portion. Compact packing of the cavernous sinus using coils should be avoided because the risk of cranial nerve deficit is high due to compression of the nerves by the coils. Bink et al., in an investigation of 19 cDAVF patients with ophthalmologic complications, demonstrated that endovascular treatment via the transvenous approach through the IPS with detachable coils led to durable angiographic cDAVF closure and effective relief of symptoms. However, there was a 44% rate of ophthalmologic signs in long-term follow-up [18]. Théaudin et al., in their study of endovascular treatment of dural carotid-cavernous fistulas, demonstrated that complete occlusion of the fistula was obtained in 87% of the patients treated via the transvenous approach, but only 25% of patients treated by the transarterial approach had the same outcome. Sixteen patients had early clinical improvement after endovascular treatment. Cerebral hemorrhage occurred in one case after transvenous embolization. During follow-up, cases treated by the transarterial route remained symptomatic, whereas 71% patients treated via the transvenous route were asymptomatic [25]. Our results from a single center experience of ten cases of transvenous cDAVF seem similar or superior to other series [8,15,26]. This may be attributed to the vigilant detection and management of possible complications. However, the low number of our cases must be considered as well. The above results suggest that coil embolization could be a stable and durable treatment for closure of cDAVF of the cavernous sinus.

Acrylic glue has been extensively used for transarterial embolization of intracranial DAVF, but there is no supportive evidence based on large series on its safety and effectiveness [27,28]. It is known that the material induces a typical sequence of thrombogenic events in the vessels (i.e., acute inflammation with mural angionecrosis followed by chronic granulomatous vasculitis), leading to delayed occlusion of the shunt, which remains stable years after the embolization procedure [29]. Paredes et al., in a report of 81 patients, demonstrated that endovascular transarterial treatment of cDAVF achieved symptomatic improvement in 78% of patients, with a complication rate of 5%[16]. By using transarterial glue embolization alone, we were able to achieve complete occlusion of the fistula in 100% of cases, with cure or improvement of symptoms in 92% of cases on clinical follow-up.

In addition, transarterial glue embolization was used in combination with transvenous approach coil embolization in ten other cases. In this approach, if the feeding artery is derived from branches of the ECA, embolization is easily performed and can decrease shunt flow. Nonetheless, achieving a complete cure is complicated in some cases because of the recruitment of a blood supply from collateral arteries and difficulty in the catheterization of the feeding arteries[30]. Therefore, a mixed approach of transarterial glue embolization and transvenous coil embolization is generally used in such cases to relieve symptoms.

Our experience shows that glue embolization is a safe method for the treatment of intracranial cDAVFs. We had only one case in which a patient was affected by ICA dissection. Careful consideration of the anatomy in each patient allowed cranial nerve complications to be avoided in our series. To achieve a higher cure rate, use of the wedged microcatheter technique with a low-concentration glue may also establish flow arrest conditions in which permeation of the glue into the venous drainage occurs by a controllable route[31,32].

Zhang et al. reported a review of 22 patients with cDAVFs who were followed for a mean of 21.6 months. Treatment was by transarterial Onyx embolization alone or transarterial and transvenous Onyx embolization. The researchers found successful obliteration of cDAVFs in 91% of cases and complete embolization in 100% of them without any recurrence. After incomplete transarterial embolization in 9% of cases, however, symptoms recurred and transvenous embolization was repeated. Transient cranial neuropathy was seen in 18% of the patients[15].

Our experience with transarterial glue embolization shows that it is an effective primary treatment for intracranial DAVFs. Further, it is a safe method of treatment when vascular anatomy is carefully considered.

A noteworthy point of our study was the lower mean age of patients in comparison with other studies: this could be partly because the general population is young. Cosmetic appearance is more important for young people, and they have a greater willingness to undergo treatment.

In conclusion, early evidence indicated that endovascular management of cDAVF is safe and effective in achieving an initial angiographic cure and a long-term clinical cure in patients who were not candidates for conservative therapy. Results of our series suggest that angiographic and clinical outcomes of endovascular embolization remain relatively stable at midterm follow-up, but large series and long-term investigations need to be designed.

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